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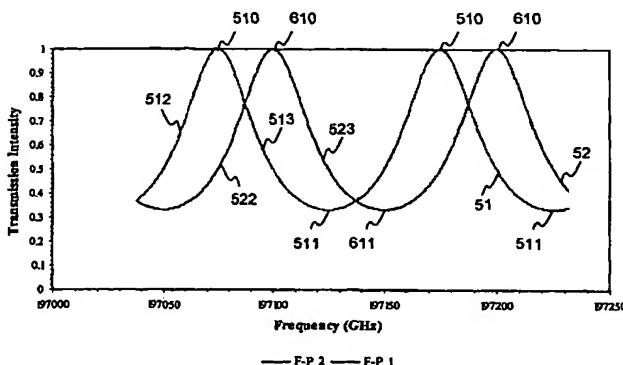
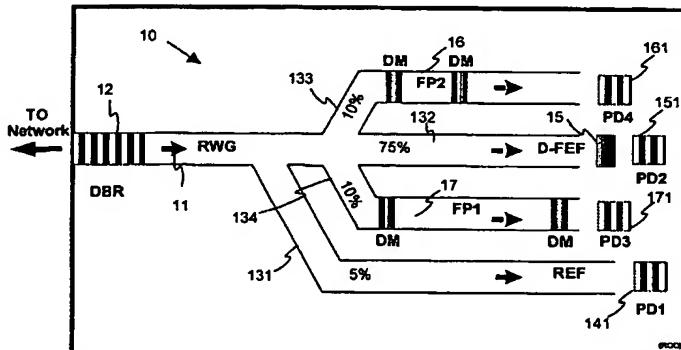
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(54) Title: OPTICAL WAVELENGTH METER



(57) Abstract: An optical wavelength meter for measuring wavelength of an optical beam includes two periodic out of phase fine optical filters (44, 45), using, for example Fabry Perot etalon filters, Fizeau filters, fibre Bragg gratings or photonic crystals. The phases of the periodic responses are arranged such that a peak (5109 or trough (511) of one response coincides with a slope (522) of the other response so that a slope portion of a response may always be chosen for measurement. A coarse filter (43) is provided to unambiguously define on which cycle of the periodic response of the fine filters a measured wavelength lies. Synchronized clock signals are provided to measure output of the filters using, for example, photodiodes (421, 422, 423, 424), at a rate of (1,000 to 10,000) wavelength measurements per second.

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**Published:**

- with international search report
- with amended claims

**AMENDED CLAIMS**

[received by the International Bureau on 14 September 2004 (14.09.04);  
original claims 1-34 replaced by amended claims 1-29]

1. An optical wavelength meter (40) for measuring an optical wavelength of an optical beam comprising:
  - a) coarse optical filter means (43) and first optical power measurement means (422) for measuring output of the coarse optical filter means and second optical power measurement means (421) for measuring an unfiltered reference beam for coarse wavelength measurement;
  - b) fine optical filter means comprising first and second periodic optical filters (44, 45) in quadrature having a finesse of substantially 2 and free spectral range of substantially 100 GHz, such that peaks and troughs of the first filter coincide with substantially linear ranges between peaks and troughs of the second filter, and third and fourth optical power measurement means (423, 424) for measuring output of the first and second periodic optical filters in quadrature for fine wavelength measurement, respectively;
  - c) beam splitting means (41) for splitting the optical beam between the unfiltered reference beam and the coarse and fine optical filter means;
  - d) synchronized clock signal measurement means for synchronized measurement of the output of the first, second, third and fourth optical power measurement means; and
  - e) processing means for determining the optical wavelength of the optical beam from a predetermined transmissivity-wavelength relationship of the coarse filter and the first and second optical power measurement means for coarse wavelength measurement and from predetermined transmissivity-wavelength relationships of the first and second periodic optical filters and at least one of the third and fourth optical power measurement means for fine wavelength measurement.
2. An optical wavelength meter as claimed in claim 1, wherein the coarse optical filter means comprises a linear spectral filter.

3. An optical wavelength meter as claimed in any of the preceding claims, wherein the coarse optical filter means comprises a dielectric multilayer coating on a glass substrate.
4. An optical wavelength meter as claimed in any of the preceding claims, wherein the periodic optical filters comprise at least one of a Fabry Perot filter, a Fizeau filter, a fibre Bragg grating and a photonic crystal.
5. An optical wavelength meter as claimed in any of the preceding claims, wherein a phase offset between the first and second periodic optical filters in quadrature is tuned by angle, temperature or pressure using a piezoelectric transducer.
6. An optical wavelength meter as claimed in any of the preceding claims, wherein reflectivity of the periodic optical filters is substantially 25%.
7. An optical wavelength meter as claimed in any of claims 1 to 6, wherein the periodic optical filters have a free spectral range of substantially 50 GHz instead of substantially 100 GHz.
8. An optical wavelength meter as claimed in any of the preceding claims, wherein the periodic optical filters are parallel or wedge quartz etalons.
9. An optical wavelength meter as claimed in any of the preceding claims, further comprising calibration filter means and calibration filter output power measuring means.
10. An optical wavelength meter as claimed in claim 9, wherein the calibration filter means comprises an etalon filter.
11. An optical wavelength meter as claimed in claim 10, wherein the etalon filter has precisely set or controllable free spectral range.
12. An optical wavelength meter as claimed in claims 10 or 11, wherein the free spectral range of the etalon filter is controllable and preset by rotation adjustment or temperature.
13. An optical wavelength meter as claimed in any of claims 10 to 12, wherein free spectral range of the calibration etalon filter differs just sufficiently from the free spectral range of the periodic optical filters that the calibration etalon filter is in phase only at top, middle and bottom wavelengths of a range of

measurements of interest to obtain co-incident or Vernier-like maximum power at those wavelengths.

14. An optical wavelength meter as claimed in any of the preceding claims, wherein at least one of the optical power measurement means comprises a photodiode.
15. An optical wavelength meter as claimed in any of the preceding claims, wherein the synchronised clock signal measurement means comprises master module (114) and slave modules (115, 116) to trigger measurement and read output of the optical power measurement means.
16. An optical wavelength meter as claimed in claim 15, wherein the synchronised clock signal measurement means enables 40,000 points on each of a plurality of channels to be read in 2.5 seconds.
17. An optical wavelength meter as claimed in any of the preceding claims, wherein, the synchronised clock signal measurement means enables 1,000 to 10,000 wavelength measurements/second.
18. An optical wavelength meter as claimed in any of the preceding claims, having a precision of substantially 2 picometers or substantially 250 MHz.
19. An optical wavelength meter as claimed in any of the preceding claims, arranged to make wavelength measurements in at least one of optical C-band, optical L-band and optical S-band.
20. An optical wavelength meter as claimed in any of the preceding claims, further comprising temperature control means for stabilising optical components thereof.
21. An optical wavelength meter as claimed in claim 20 wherein the temperature control means comprises a thermistor or thermocouple and fan cooling or Peltier temperature elements.
22. An optical wavelength meter as claimed in any of the preceding claims, adapted for external triggering for synchronisation with external instrumentation.
23. An optical wavelength meter as claimed in any of the preceding claims arranged to measure infrared or visible wavelengths.

24. A method of determining wavelength of an optical beam comprising:

- a) splitting the optical beam into first, second, third and fourth sub-beams;
- b) presenting the first sub-beam to reference first photodetector means (421);
- c) presenting the second sub-beam to coarse filter means (43) having an output to second photodetector means (422);
- d) presenting the third sub-beam to a first fine periodic filter (44) having an output to third photodetector means (423);
- e) presenting the fourth sub-beam to a second fine periodic filter (45) having an output to fourth photodetector means (424), wherein the first fine periodic filter and the second fine periodic filter are in quadrature and have a finesse of substantially 2 and free spectral range of substantially 100 GHz, such that peaks and troughs of the first fine periodic filter coincide with substantially linear ranges between peaks and troughs of the second fine periodic filter;
- f) using synchronized clock signal measurement means to read outputs from the first, second, third and fourth photodetector means;
- g) identifying from predetermined transmissivity-wavelength characteristics of the coarse filter means and the first and second photodetector means outputs a limited range of wavelength in which the wavelength of the optical beam lies, to determine from their predetermined transmissivity-wavelength sensitivities which of the first fine filter and the second fine filter has a greater sensitivity to wavelength in that limited range; and
- h) using predetermined transmissivity-wavelength characteristics of the first or second fine filter having the greater sensitivity in the limited range of wavelength and the corresponding third or fourth photodetector means output, corresponding to the fine filter means having the greater sensitivity, to determine the wavelength of the optical beam.

25. A method as claimed in claim 24, comprising the further steps of:
  - a) providing a calibration etalon filter with conventional Airy function transmitting only at a reference wavelength for calibration having a common maximum with the first and second fine periodic filters respectively at a limited number of wavelengths within range;
  - b) providing a broadband light source; and
  - c) calibrating the processed readout from fine periodic filters to the reference wavelength of the calibration etalon filter.
26. A method as claimed in claim 25, wherein step b) alternatively comprises providing a tuneable laser tuned to the reference wavelength.
27. A method as claimed in claim 25, wherein step a) additionally comprises providing a fourth Airy etalon in ratio with the third Airy etalon to provide a common maximum at the limited number of wavelengths for a more defined optical transmitted bandwidth.
28. A method as claimed in any of claims 24 to 27, for measuring infrared or visible wavelengths.
29. A computer program comprising code means for performing all the steps of the method of any of claims 24 to 28 when the program is run on one or more computers.